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The optimum characteristics for a simple luminance notch in a PAL colour television decoder

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RESEARCH DEPARTMENT

THE OPTIMUM CHARACTERISTICS FOR A SIMPLE LUMINANCE NOTCH IN A PAL COLOUR TELEVISION DECODER

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(PH-82)

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Summary

The various considerations which govern the characteristics of a luminance notch filter in a PAL decoder are discussed and subjective experiments are described which were carried out to find the optimum characteristics of such a filter.

1. Introduction

It is normal practice, with the colour television systems currently used, for decoding equipment to include a filter to remove the multiplexed chrominance information from the luminance signal. The effects of displaying this information, in subcarrier form, are known to result in the presence of visibly annoying subcarrier patterns and the desaturation of coloured areas.

Various methods of removing the chrominance information exist in practice, ranging from a simple low-pass filter which has a cut-off frequency below the lower-sideband limit of the chrominance signal, to sophisticated methods using comb filters which separate the interleaved luminance and chrominance spectra. The former method is crude and results in a great loss of luminance-signal detail, while the latter method is considered too expensive and too complicated for general use in decoders and domestic colour receivers. As a compromise, a subcarrier trap circuit resonant at the subcarrier frequency,[1,2] which provides a 'notch' in the luminance characteristic, can effectively remove most of the unwanted chrominance information from the luminance signal. Such an arrangement is widely used in NTSC, PAL and SECAM decoders and receivers.

2. Notch characteristics

There are certain limitations imposed on the characteristics of a notch which result in a compromise between the attenuation, or notch depth, at subcarrier frequency and the bandwidth between the 3 dB attenuation points. As the chrominance information is made up of sidebands around the subcarrier frequency, the notch is required to have a bandwidth sufficient to embrace most of these, in addition to suppressing the subcarrier adequately, otherwise objectionable edge effects are seen on some colour transitions; these can be particularly noticeable in small areas of saturated colour, e.g. the players' shirts in a wide lens-angle view of a football match. However, the bandwidth of the notch must not be so wide that the amount of high-frequency luminance information removed is excessive.

A further undesirable effect of a simple notch in the luminance channel is the production of high-frequency "ringing" effects. These take the form of damped oscillations at the resonant frequency of the notch, following sharp luminance transitions, which increase in amplitude with the 'Q' factor and the depth of the notch. To some extent the visibility of these can be reduced by means of phase equalisation of the notch, which effectively redistributes the energy of the "ring" signals, so that they occur with reduced amplitude both before and after the transition.

The performance of a filter for removing chrominance information from the luminance signal would ideally remove the maximum amount of chrominance information with the minimum amount of distortion to the luminance signal. However, there does not yet appear to be an accepted practical characteristic to which notch filters in decoders for PAL System I should generally conform and no recommendations are made in the specification of the BREMA Reference Colour Receiver.[3] In some early decoders very wide notch filters were used. These had a bandwidth equal to the maximum bandwidth specified for the transmitter chrominance signals; this practice was possibly due to the difficulty in subjectively separating the effects of spurious signals produced by the chrominance demodulators and residual chrominance subcarrier accompanying the luminance signal. The application of integrated-circuit techniques for chrominance demodulators has now resulted in 'cleaner' decoded colour-difference signals so that it is now possible to evaluate the optimum luminance notch-width more effectively.

This report describes an investigation carried out to establish subjectively the optimum characteristics for a simple notch filter for professional PAL decoding equipment.

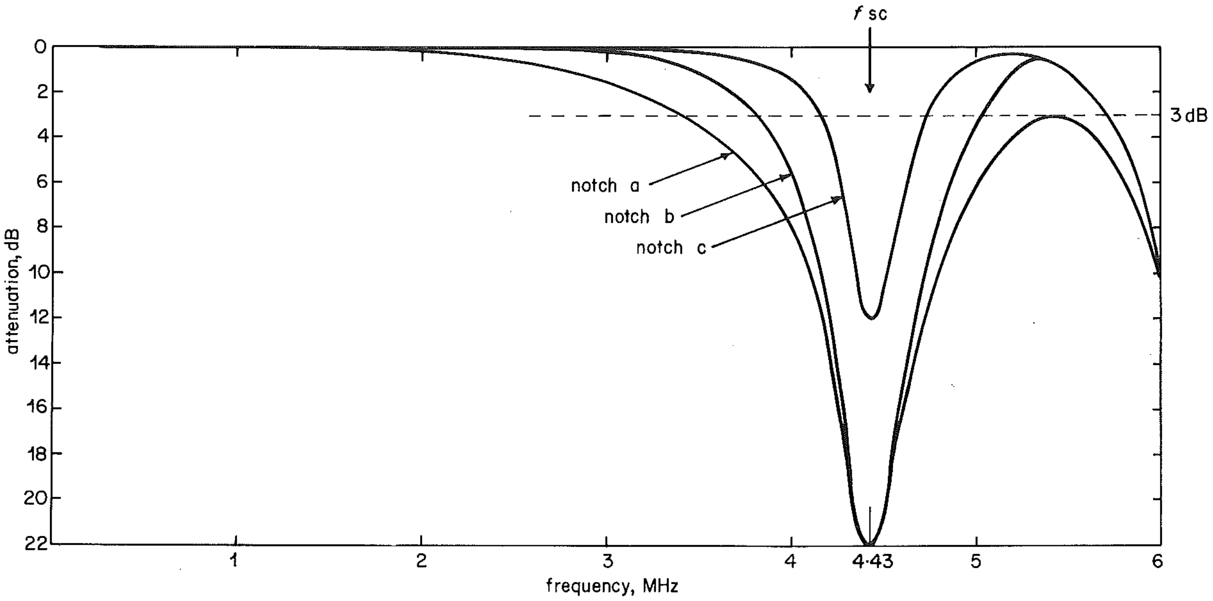

Fig. 1 - The characteristics of the luminance notches used in the tests

3. Experimental method

Three commercially-manufactured PAL decoders of modern design were modified so as to contain luminance notch-filters with different bandwidths and depths; the characteristics of the three notches are shown graphically in Fig. 1. The attenuation values at subcarrier frequency and the effective bandwidths (between 3 dB attenuation points) were:—

Notch (a)	22 dB,	2 MHz
Notch (b)	22 dB,	1·2 MHz
Notch (c)	12 dB,	0·56 MHz

The three decoders, which were checked to have identical performances in all other respects, were fed with a common input signal. By means of a simple changeover switch their output signals could be selected, in turn, and displayed on a colour monitor with good resolution which was considered to be representative of a modern colour display.

A series of subjective tests were then carried out in which observers were shown pictures of the same subject matter, derived from each decoder in turn (in a non-regular sequence) and were asked to grade the pictures in respect of five different features. These were:

(i) General sharpness
(ii) High-frequency ringing at luminance edges
(iii) Chrominance sideband effects on edges
(iv) Visibility of subcarrier patterning
(v) Desaturation effects

The tests were carried out at intervals over a number of days and the subject matter used in the different tests was varied over a wide range. Pictures derived from closed-circuit colour sources and test cards were included, and broadcast programme pictures originating from studios, outside broadcasts and films were also used.

A limited number of experienced technical observers carried out the appraisals using the EBU six-point Quality Scale for sharpness and the EBU six-point Impairment Scale for the other four features.

The viewing distance for the tests was six times the picture height.

4. Discussion of results

The first set of results, given in Table 1, were obtained using only test-chart as the subject matter; these are given separately to show that the notch characteristics were sufficiently varied to produce significantly different results when viewing a critical test subject. Changing from notch (c) (narrow) to notch (a) (wide) gave a reduction in the quality of sharpness of the picture of about one grade. On the other hand, for the same change, the impairment caused by the chrominance sidebands was reduced by almost two grades.

In Table 2 the average gradings are given for the complete range of picture subject matter, including the test chart. These gradings are generally lower than those given in Table 1; the absence of a suitable reference for assessing resolution in most of the pictures resulted in the observers giving a less critical opinion of picture sharpness.

TABLE 1

Average Subjective Grading for Test Chart

	Luminance Notch		
	a Wide	b Medium	c Narrow
Picture Sharpness*	2·6	2·1	1·5
Luminance Edge Ringing	1·5	1·9	2·0
Chrominance Sidebands	1·0	1·9	2·8
Subcarrier Visibility	1·0	1·2	1·5
Desaturation	1·6	1·5	1·5

TABLE 2

Average Subjective Grading for Various Pictures

	Luminance Notch		
	a Wide	b Medium	c Narrow
Picture Sharpness*	2·2	2·2	1·9
Luminance Edge Ringing	1·1	1·1	1·2
Chrominance Sidebands	1·3	1·5	2·0
Subcarrier Visibility	1·1	1·2	1·4
Desaturation	1·1	1·1	1·1

* Quality Scale	Impairment Scale
1 Excellent	1 Imperceptible
2 Good	2 Just perceptible
3 Fairly good	3 Definitely perceptible but not disturbing
4 Rather poor	4 Somewhat objectionable
5 Poor	5 Definitely objectionable
6 Very poor	6 Unusable

The average grades obtained for sharpness with the three different notches are all very similar and the general assessment for all the pictures was good.

To a large extent the picture impairments affected by both the depth and width of a luminance notch are clearly interdependent and to arrive precisely at the optimum parameters for both, would require the tests to include the effects of a far wider range of notch characteristics. However, the parameters of the three notches used in these tests were limited to those found in current professional decoders and thought to be representative of characteristics accepted as providing an adequate performance. Nevertheless, it appears from Table 2 that in viewing varied subject matter there is a large tolerance permissible in the specification of the notch. This tolerance is similar to the maximum differences between the parameters of the three notches examined. Within these limits picture sharpness remains good and the other impairments remain generally less than just perceptible.

To be more conclusive it is necessary to re-examine the results given in Table 1 for more critical subject matter, where it appears that the pictures retain good sharpness while the impairments remain imperceptible only in the case of notch (b).

Residual subcarrier and desaturation effects in large coloured areas, which are mainly a function of notch depth, never become perceptible in any of the tests although the minimum depth of the notches used was 12 dB. Similarly, the visibility of chrominance sidebands did not become excessive with the shallow notch although this impairment is mainly a function of notch width. These results suggest that the maximum notch depth could be somewhat less than the 22 dB of notch (b) and it is likely that a depth between 12 and 18 dB would provide adequate protection.

5. Conclusions

The main subjective considerations determining the parameters of a simple luminance notch-filter are the visibility of the subcarrier in large coloured areas, the visibility of chrominance sidebands in the region of colour transitions and the loss of picture sharpness. The results of the subjective tests indicate that, for a good compromise between these requirements, the optimum luminance notch characteristics, for a PAL System I decoder, approximates to: (i) an attenuation at subcarrier frequency of between 12 and 18 dB and (ii) a bandwidth between the 3 dB attenuation points of ±600 kHz about subcarrier frequency.

In order to obtain more positive results, further extensive tests would be required using a greater number of notches with smaller differences between their parameters, and the subject matter in such tests would have to be confined to test patterns.

6. References

1. Colour television. NTSC System Principles and Practice and Townsend (Iliffe), Vol. 1, p. 206, Vol. 2, p. 120 and 211.
2. Colour television engineering. Wentworth (McGraw-Hill), p. 375.
3. The Radio and Electronic Engineer, Vol. 38, No. 4, p. 204, October 1969.

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